Spatial and temporal modelling of heavy metal contaminant loadings to urban streams

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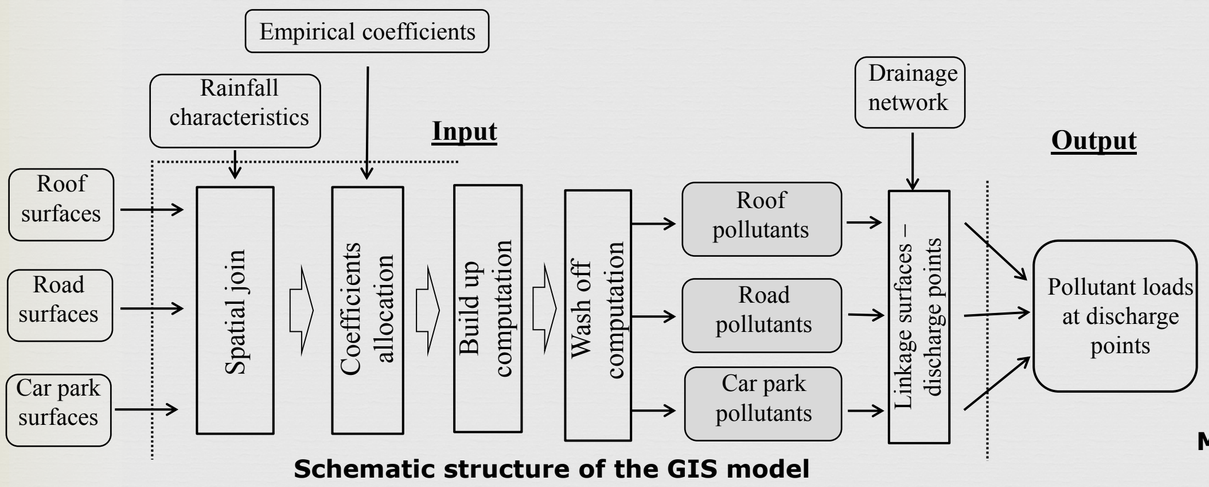
Introduction

Urban stormwater contains substantial amounts of heavy metals (**Zn, Cu, Pb**) and suspended solids (**TSS**). Untreated, these contaminants are recognized as the main detriment to urban waterways. To quantify the sources of these pollutants in urban catchments and resulting discharges to specific points along waterways, the MEDUSA (**M**odelled **E**stimates of **D**ischarges for **U**rban **S**tormwater **A**ssessments) modelling framework was developed.

Methodology description

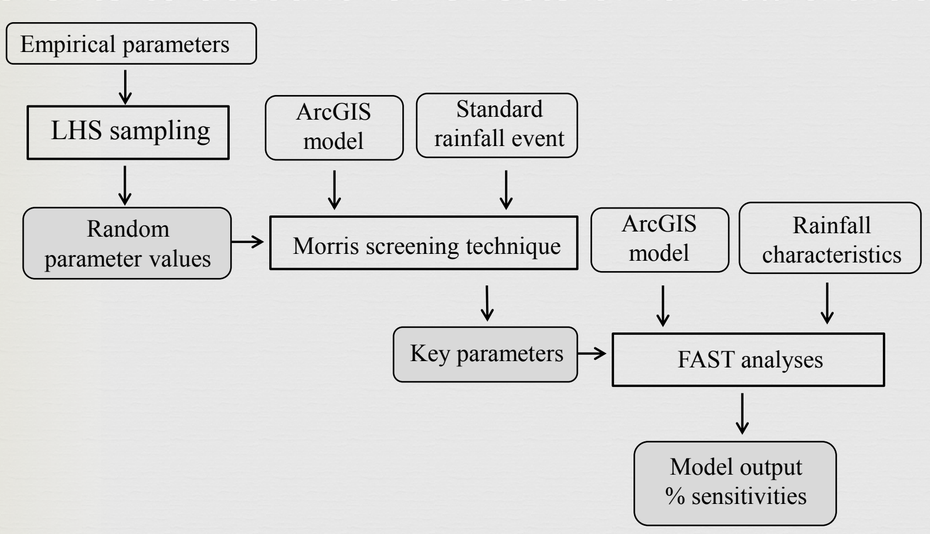
MEDUSA is a GIS-based contaminant source and discharge model with a sensitivity analysis and calibration process.

GIS model: Quantifies pollutant build-up and wash-off from different roofs, roads, and car park impervious surfaces. Contaminant yields conveyed into the waterway at each discharge point are predicted. The model requires delineating all impervious surfaces and their material types, the drainage network, rainfall characteristics and coefficients for pollutant dynamics.

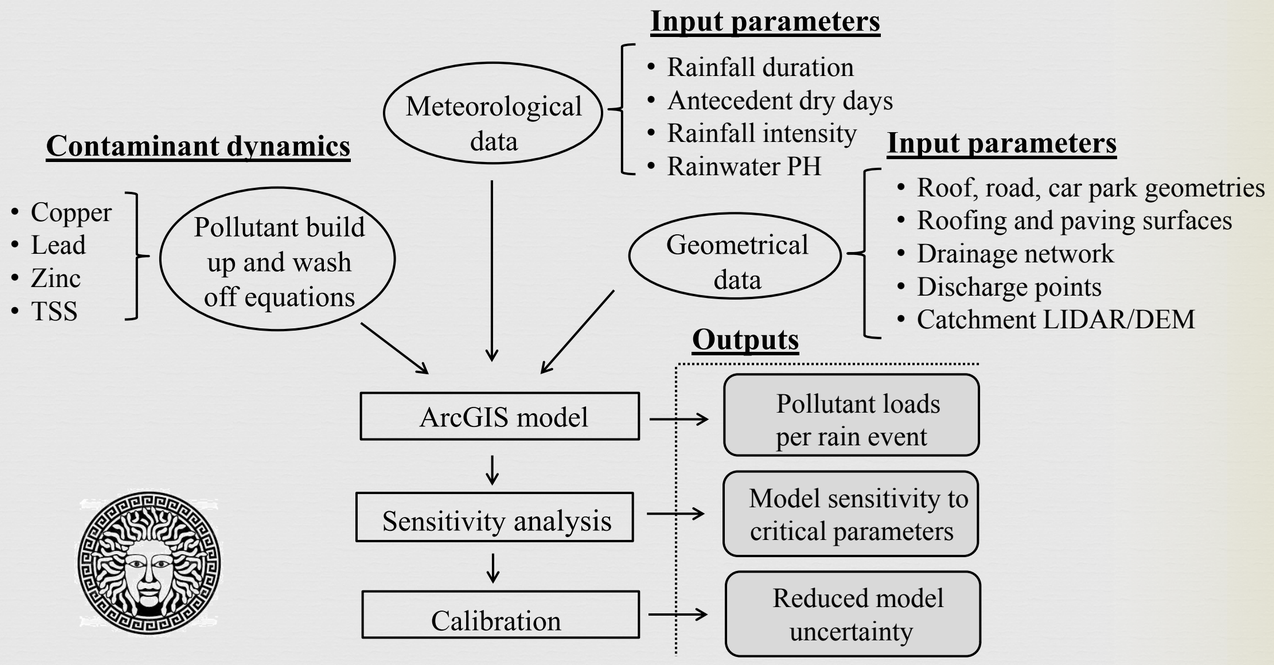


Schematic structure of the GIS model

Sensitivity analysis and calibration process: Identifies key parameters influencing each pollutant load using LHS, Morris screening and FAST sensitivity tools. Calibration of these parameters can then be optimized. The process is repeated for different rainfall events to account for effects of rainfall characteristics.



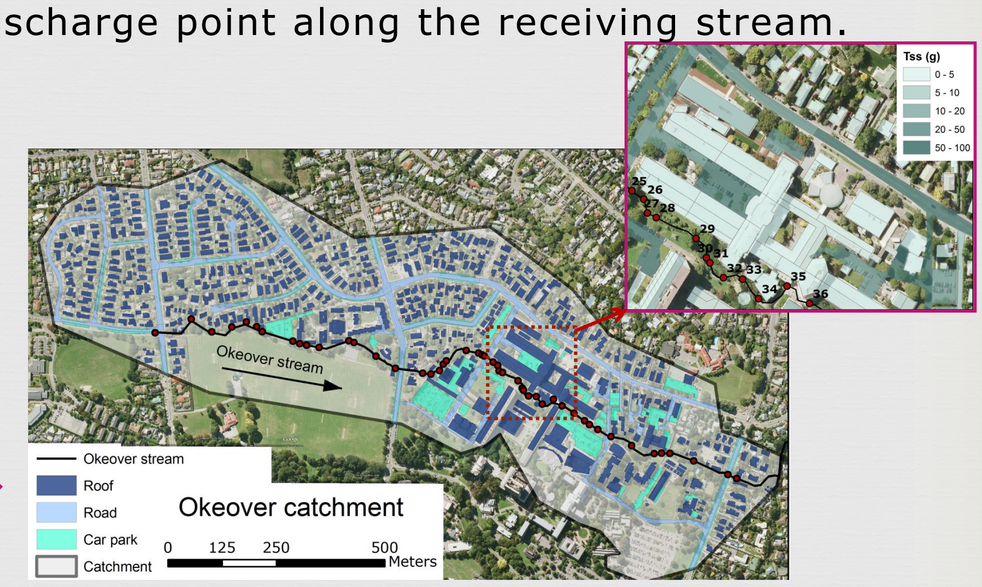
Sensitivity analysis, showing inputs (hollow boxes) and outputs (filled boxes)



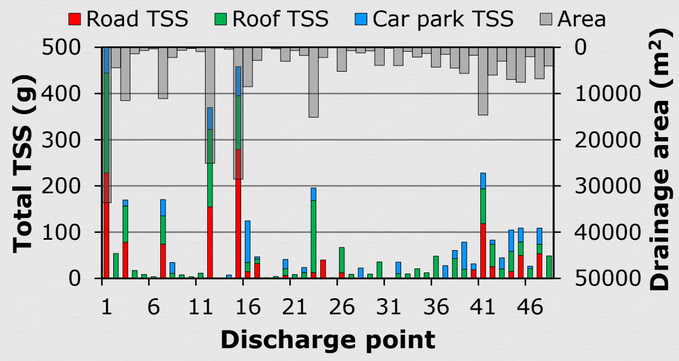
The MEDUSA (**M**odelled **E**stimates of **D**ischarges for **U**rban **S**tormwater **A**ssessments) **framework**

Application and results

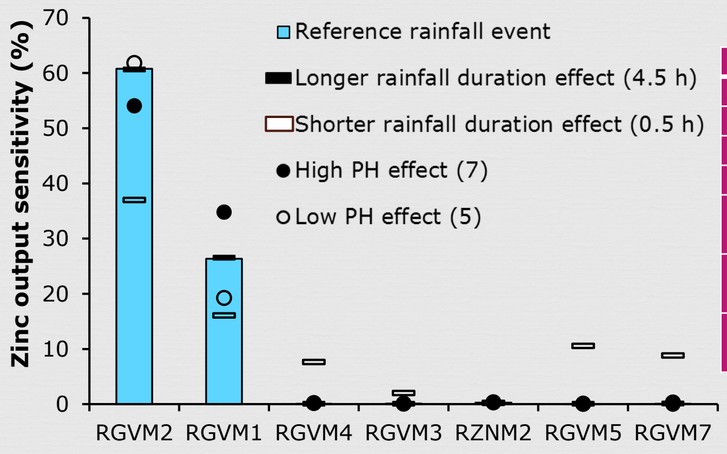
MEDUSA was applied to the older Okeover catchment (Christchurch) to compute the amount of pollutants generated from every impervious surface and their corresponding contaminants yielded at each discharge point along the receiving stream.



Model input for the Okeover catchment (above). TSS Build-up in the same catchment (insert)



TSS loads at discharge points for a single rain event



Param.	Description
RGVM1	Stationary Zn concentration in galvanised roofs (pH coefficients)
RGVM2	
RGVM3	Initial Zn concentration in galvanized roofs (pH coefficient)
RGVM4	
RGZNM2	Stationary Zn concentration in zincalume roofs (pH coefficient)
RGVM5	Initial Zn concentration in galvanized roofs (antecedent dry days effect)
RGVM7	Initial Zn concentration in galvanized roofs (rainfall intensity effect)

Sensitivity indices for most relevant Zn parameters under different rainfall conditions

Conclusions

1. New modelling framework (MEDUSA) to quantify temporal and spatial contaminant loadings to urban waterways.
2. GIS-based model computes pollutant build-up and wash-off, using information of impervious surface types, drainage network and rainfall characteristics. It can also be used to identify sources and critical discharges of pollutant loads, prioritising management practices.
3. Model sensitivity of the parameters evaluated through a series of sensitivity tools. This identifies the main influencing variables and therefore allows prioritising calibration of those in order to optimize resources for increasing model accuracy.